High-Accuracy Measurement of SiGe Chips by Inductively Coupled Plasma Optical Emission Spectroscopy

The Surface and Microanalysis Science Division of NIST is leading an effort in conjunction with the semiconductor industry to provide chemically characterized SiGe reference materials to be used for validation of analytical methodologies. The Analytical Chemistry Division has participated in this effort by developing and applying an inductively coupled plasma-optical emission spectroscopy (ICP-OES) method that can be used to determine accurately and precisely the Ge atom fractions in SiGe alloys.

S.A. Rabb, M.R. Winchester, and L.L. Yu (Div. 839)

Silicon germanium (SiGe) technology has played a significant role in the development and success of the wireless and computer industries. The fabrication process using this technology is very similar to that for silicon-based chips. Therefore, only small changes in production are required, allowing for lower costs. SiGe devices can also be smaller, with reduced noise and higher frequencies, while maintaining the same low power requirements as Si devices. These favorable qualities make SiGe technology competitive with more expensive counterparts based on group III-V semiconductors, such as gallium arsenide (GaAs) and indium phosphide (InP). As the popularity of SiGe technology continues to advance in today's electronics market, characterization of these semiconductors becomes more vital.

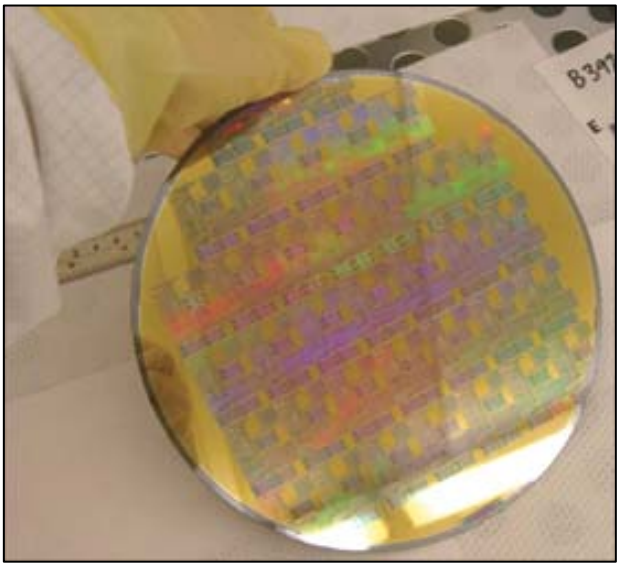
As the market for SiGe technology grows in the semiconductor industry, accurate characterization of SiGe materials is needed to ensure the quality of these materials and protect the economic interests of the semiconductor industry. However, reference materials do not exist to validate the methods used to characterize these materials. As part of an effort to provide SiGe reference materials, an ICP-OES method was developed to enable very accurate and precise determinations of Ge atom fractions in SiGe alloys. This method was then applied to SiGe candidate reference materials provided by the semiconductor industry.

SiGe chips of three different nominal Ge atom fractions (3.5 %, 6.5 %, and 14 %) were analyzed. All chips were digested at ambient temperature in capped polyethylene bottles to prevent the potential loss of Si in the presence of HF. The recoveries of Si and Ge after acid digestion of multiple Si and Ge metal pieces were observed to be 100.0 % ± 0.2 % for both analytes. Analyses were conducted using high-performance ICP-OES (HP-ICP-OES).

HP-ICP-OES utilizes multiple measurements of every standard and sample in a randomized sequence. Correction for drift is accomplished by fitting a polynomial equation (up to sixth order) to the data for all standards and samples as a function of time, then applying correction factors derived from the fitted equation. Analyte concentrations in the standards and samples were closely matched to prevent uncertainties caused by nonlinearity and/or a non-zero intercept in the calibration.

The Ge atom fractions were successfully determined using the HP-ICP-OES methodology. Relative expanded uncertainties (95% confidence) were on the order of 0.2 % for all SiGe chips analyzed. The HP-ICP-OES values for these materials will be used in conjunction with INAA for assignment of certified values.

Availability of SiGe reference materials will allow the semiconductor industry to validate analytical methods.



Future Plans: HP-ICP-OES analyses will be performed as needed to assist in the production and certification of additional SiGe reference materials.